IMPROVEMENTS IN THE PRACTICAL METHODS OF ASSESSMENT OF LOSSES CAUSED BY INSECTS IN GRAIN STORED AT THE VILLAGE LEVEL IN TROPICAL AFRICA

A. RATNADASS
ICRISAT/IRAT West African Sorghum Improvement Program
B.P.320 Bamako - Mali

F. FLEURAT-LESSARD
INRA, Laboratoire des Insectes des Denrées
B.P.81, 33883 Villenave d'Ornon Cedex -France

ABSTRACT - The application of variants of the Thousand Grain Mass method and of the Count and Weigh method for assessing weight losses caused by insects during the storage of maize, paddy rice and sorghum grain in villages of Côte d'Ivoire and Central African Republic has allowed a new improvement in the second method, which enables a good correlation of loss level with a biologically unbiased criterion.
In this study realized under field laboratory conditions as also regarding the grain variability and the sampling pattern required, the second method proves to be by far the most practical and accurate.
The implications of these results are discussed in the view of a field application for loss assessment programs.

Key words: stored grain insect pests, weight loss assessment, Count & Weigh Method, Thousand Grain Mass Method, maize, paddy rice, sorghum, Côte d'Ivoire, Central African Republic.

RESUME - Amélioration des méthodes pratiques d'évaluation des pertes occasionnées par les insectes au grain stocké au niveau villageois en Afrique tropicale.

L'application de variantes de la méthode de la Masse de Mille Grains et de la méthode de Comptage et Pesée pour l'estimation des pertes pondérales causées par les insectes pendant le stockage du maïs, du riz paddy et du sorgho dans des villages de Côte d'Ivoire et de République Centrafricaine a permis d'apporter une nouvelle amélioration à la seconde méthode, qui autorise une bonne corrélation entre le niveau de perte et un paramètre sans biais biologique.
Dans cette étude réalisée dans des conditions de laboratoire de terrain, et en regard de la variabilité du grain et de la technique d'échantillonnage requise, la deuxième méthode s'avère être de loin la plus pratique et précise.
Ces résultats et leurs implications sont discutés dans l'optique de leur application pratique pour des programmes d'estimation des pertes.

Mots clés: Insectes ravageurs des stocks de grain, estimation de la perte pondérale, méthode de Comptage et Pesée, méthode de la Masse de Mille Grains, maïs, riz paddy, sorgho, Côte d'Ivoire, République Centrafricaine.

INTRODUCTION

Insects are a major cause of stored grain losses, particularly in tropical countries. The reduction of dry weight resulting from

the development of insects (expressed as a percentage) is one of the important criteria allowing the characterization of the level of deterioration and storage ability of the grain (Anon., 1969). For practical reasons, the quality of all a stock of grain must be judged on the basis of a representative sample (Golob, 1976). Besides sampling hazards, there is no real standardization of techniques for estimating dry weight loss in stored grain.
However, several practical methods have been used, which fall into two main groups: (i) methods which refer to an adequate baseline sample, to which the studied sample is compared, namely the weight of a standard volume of grain ('Standard Volume Weight (SVW) Method'; Adams and Schulten, 1978) or of a fixed number of grains ('Thousand Grain Mass (TGM) Method'; Proctor and Rowley, 1983); (ii) methods which compare the mean weight of damaged and undamaged kernels from within the same sample, either directly ('Count and Weigh (C&W) Method'; Anon., 1969), or by multiplying the percentage of damaged kernels by a conversion factor ('Converted Percentage Damage (CPD) Method'; Adams and Schulten,1978).
Practical examples of the application of these methods have shown their limitations, particularly under either very high or very low insect infestation, and have led to set up improvements, notably to overcome the problems linked to mean kernel weight variability ['Expanded C&W Method' (Schulten, 1982; Boxall, 1986) and 'Multiple TGM Method' (Proctor and Rowley, 1983)] and to 'hidden infestation' (Fleurat-Lessard, 1982) [dissection of individual grains (De Lima, 1979)].
Recently, Reed (1986) discussed the main methods of dry weight loss estimation in stored grain, focusing on what is known on their precision, accuracy and limitations, using the 'Weigh-In, Weigh-Out Method' as a standard against which he compared other loss estimation techniques.
This paper presents the results of the application at the village of the TGM and C&W methods and some of their variants, in order to obtain original improvements in the C&W method.

MATERIALS AND METHODS

1. Grain sampling

Grain samples of 0.5 to 1.5 kg were taken in maize and paddy rice stores in villages of Côte d'Ivoire (CI) during 1983/1984 storage season, and in sorghum stores of the Central African Republic (CAR) during 1985 and 1986 storage seasons.
In CI, maize is stored on the cob, either with or without husks, or shelled in bags, only one variety, local or improved, being stored in a granary. Paddy rice is stored in sheaves of heads of the same variety of about 2.5 kg each, several sheaves of different local varieties being stored in a granary. In CAR, several local varieties of sorghum are stored mixed and loose in the same granary.
In the village stores surveys, the chronological approach (Adams, 1978) was used and the samples taken from the part of the granary where its owner drew the grain for self-consumption. In CAR, maize seeds of improved varieties stored in two seed multiplication centers was also sampled, using a compartmented bag probe. More details on these studies (such as location of granaries, selection criteria, sampling pattern, etc...) have been published elsewhere (Ratnadass and Sauphanor, 1988; Ratnadass, 1990).

2. Laboratory measurements

After sieving for insects and frass (2.36 mm aperture size sieve), samples were reduced with a Humboldt[R] sample divider (box type) into subsamples for moisture content (M.C.) and dry weight loss determination.

M.C. was measured with Dole[R] or Dickey-John[R] quick moisture meters (capacitance type). Dry weight loss was measured by using variants of the C&W and of the TGM methods. The technique used in CAR was the 'Expanded C&W Method' (Schulten, 1982; Boxall, 1986), i.e. with separation of grains into two categories of size, using adapted sieves: aperture size of 3.36 mm for sorghum and of 8.00 mm for maize. In each size category, apparently sound grains were separated from damaged (holed) ones; grains in each fraction were counted, and the whole fractions weighed; the dry weight loss was given by the following formula (1):

$$\%\ \text{weight loss} = \frac{\text{Wt UN} - \text{Wt of sample}}{\text{Wt UN}} \times 100 \qquad (1)$$

$$\text{with} \quad \text{Wt UN} = \frac{\text{Wt UN.L.G.}}{\text{N UN.L.G.}} \times \text{T.L.G.} + \frac{\text{Wt UN.s.g.}}{\text{N UN.s.g.}} \times \text{T.s.g.}$$

where Wt = weight and N (or T) = number

Wt UN =	weight of undamaged sample
Wt UN.L.G. =	weight of apparently undamaged large grains
N UN.L.G. =	number of apparently undamaged large grains
T.L.G. =	total number of large grains
Wt UN.s.g. =	weight of apparently undamaged small grains
N UN.s.g. =	number of apparently undamaged small grains
T.s.g. =	total number of small grains

[When the same analysis, including M.C. measurement, had been performed on a baseline sample taken at the beginning of the storage period, it was possible to calculate dry weight loss using the 'Multiple TGM Method' (Proctor and Rowley, 1983), with the following formula (2):

$$\%\ \text{weight loss} = \frac{(WP1 + WP2) - (Wx1 + Wx2)}{WP1 + WP2} \times 100 \qquad (2)$$

$$\text{with } WP1 = \frac{M1}{MX1} \times Wx1 \quad \text{and} \quad WP2 = \frac{M2}{Mx2} \times Wx2$$

where M1 = dry weight of 1000 large grains in the baseline sample
M2 = dry weight of 1000 small grains in the baseline sample
Mx1 = dry weight of 1000 large grains in the work sample
Wx1 = wet weight of the large grains in the work sample
Mx2 = dry weight of 1000 small grains in the work sample
Wx2 = wet weight of the small grains in the work sample]

The four fractions of the same sample (or 12 fractions when loss had been assessed on three subsamples) were kept in laboratory conditions inside translucent plastic containers. The samples

were sieved every three to seven days, for a total period of 45 days, to take into account the 'hidden infestation'. Emerging adults were withdrawn at each sieving so that the females could not lay eggs into the grain.
A second estimate of weight loss with the Expanded C&W Method was performed at the last sieving, when no more emergences of adults were observed.
In CI survey, only one loss estimate was made. Paddy rice grains were not separated in categories of size, so that only 'Simple' C&W and TGM methods could be used. Maize kernels were separated visually.

RESULTS

Most damaging insect species were (Ratnadass et Sauphanor, 1988; Ratnadass, 1990):
- *Sitophilus zeamais* Motschulsky (*Coleoptera; Curculionidae*) on maize;
- *Sitotroga cerealella* (Olivier) (*Lepidoptera; Gelechiidae*) and *Sitophilus oryzae* (L.) (*Coleoptera; Curculionidae*) on paddy rice;
- *S. oryzae* on sorghum.

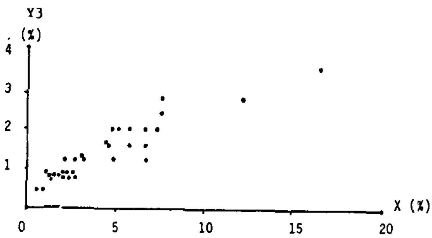
In the case of paddy rice, a strong correlation was found between the percentage of damaged grains (X) and the percentage of weight loss (Y1) calculated with the Simple C&W Method ($P < 0.0001$, the equation $Y1 = 0.54X + 0.27$ (3) accounting for 98% of the global variance), while no correlation was found between X and Y1 calculated with the Simple TGM Method, because of several 'negative losses' (Table 1).
The 95% confidence interval for the weight loss mean (obtained from three 500 to 1000 grain subsamples) was $\pm$ 1.8%.
In the case of maize cobs stored with husks, a strong correlation was also observed between the percentage of damaged grains (X) and the percentage of weight loss (Y2) calculated with the Simple C&W Method (Table 2): $r = 0.973$, $P < 0,0001$. The correlation was even better when using the Expanded C&W Method, i.e. with grains being separated visually into two categories of size ($P < 0.0001$, the equation $Y2 = 0.20X - 0.68$ (4) accounting for 98% of the global variance) while the correlation between X and Y2 calculated with the Multiple TGM Method was poor ($r = 0.469$, not significant).
Fig.1 confirms the strong correlation between the percentage of damaged grains (X) and the percentage of weight loss (Y3) calculated with the Expanded C&W Method in the case of maize cobs stored with husks ($P < 0.0001$, the equation $Y3 = 0.20X + 0.11$ (5) accounting for 88% of the global variance). The correlation coefficient is still higher ($r = 0.952$) after a double transformation (X into $\log(1 + X)$ and Y3 into $\log(1 + Y3)$.
In the case of maize stored as dehusked cobs (Fig.2), a good correlation between the percentage of damaged grains (X) and the percentage of weight loss (Y4) calculated with the Expanded C&W Method has also been observed ($P < 0.0001$, the equation
$Y4 = 0.27X - 0.56$ (6) accounting for 86% of the global variance). The correlation coefficient is still higher ($r = 0.982$) after a transformation of Y4 into $\log(1+Y4)$.
The 95% confidence interval of the weight loss mean (obtained from three about 200 grain subsamples) ranged from $\pm$ 0.7 for slightly attacked grain to $\pm$ 3.5 for more heavily attacked grain.
For maize stored as shelled grain, there was a strong correlation

Table 1. Comparison of different loss estimates on 15 paddy rice samples taken in village stores (Côte d'Ivoire, 1984)

# of sample	% damaged grains	% weight loss Simple C&W	% weight loss Simple TGM
1	0.7	0.3	-22.7
2	0.8	0.6	+ 0.4
3	1.9	1.1	+ 2.9
4	2.0	1.3	+ 3.2
5	2.1	1.5	- 5.2
6	2.2	1.7	-24.1
7	2.2	1.2	-38.3
8	3.0	1.7	-24.1
9	3.0	1.4	-14.1
10	5.6	3.4	-15.3
11	5.9	3.4	- 3.1
12	7.7	4.7	+20.4
13	11.7	7.7	-22.9
14	23.5	14.2	+ 4.7
15	29.3	14.6	+29.8

Table 2. Comparison of different loss estimates in maize grain samples taken in Oumé (Côte d'Ivoire) village stores (storage on the cob, with husks)

# of sample	1	2	3	4	5	6	7
% damaged grains	2.8	3.8	6.4	19.4	21.6	25.0	62.5
% weight loss (Expanded C&W Method)	0.7	0.2	0.6	2.1	3.8	4.1	12.3
% weight loss (Simple C&W Method)	0.6	0.2	0.7	1.2	3.5	3.4	13.3
% weight loss (Simple TGM Method)	-2.5	9.4	-7.6	4.7	3.0	11.0	8.2



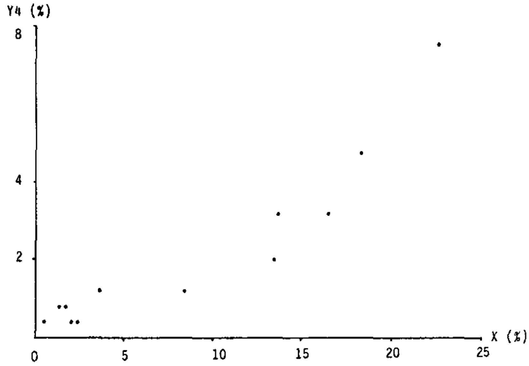


Figure 1. Plot of percentage weight loss (Y3) calculated with the Expanded Count and Weigh Method against corresponding percentage damaged grains (X) in the case of samples of maize stored on the cob with husks (Côte d'Ivoire survey, February 1984)

Figure 2. Plot of percentage weight loss (Y4) calculated with the Expanded Count and Weigh Method against corresponding percentage damaged grains (X) in the case of samples of maize stored on the cob without husks (Côte d'Ivoire survey, February 1984)

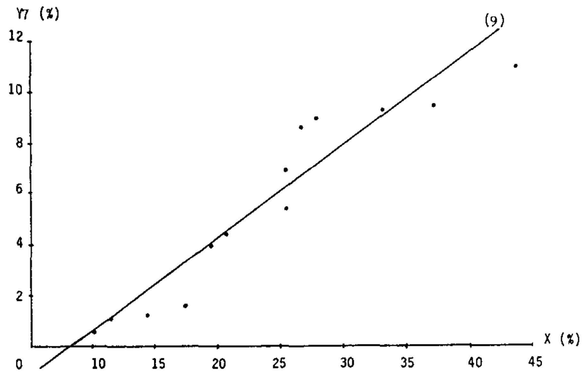


Figure 3. Correlation between percentage damaged grains (X) and second estimation of percentage weight loss (Y7) calculated with the Expanded Count and Weigh Method in the case of samples of sorghum grain stored loose (CAR survey, 1986) (equation (9) : $Y7 = 0.36\ X - 1.15$)

between the two estimates of the percentage of damaged grains (respectively at the time of sampling and after all hidden infestation had emerged) and the percentage of weight loss calculated with the variants of the C&W method (Tables 3 to 6).
The correlation was good between the percentage of damaged grains and the percentage of loss calculated with the Multiple TGM Method in the first case (variety suffering high levels of insect attack), whereas there was no correlation between these two parameters in the second case (variety suffering only low levels of attack). The strongest correlations were those between the second estimates of the percentage of damaged grains (X) and of weight loss (Y5). In the first case (heavy infestation), the equation $Y5 = 0.22X - 2.27$ (7) accounted for 91% of the global variance, while in the second case (slight infestation) the equation $Y6 = 0.28X + 0.10$ (8) accounted for 98% of the global variance. In the case of the heavily attacked variety, the correlation coefficient is still higher after a conversion of Y5 into $\log(1 + Y5)$: $r = 0.986$.
The 95% confidence interval of the weight loss mean (first estimate with the Expanded C&W Method) obtained from three subsamples of about 300 grains each was $\pm$ 3.9%.
Results on loose storage of a mixture of several local varieties of sorghum in CAR have been detailed elsewhere (Ratnadass, 1990). Table 7 shows the good correlation that was found between the percentage of damaged grains and the percentage of weight loss calculated with diverse variants of the C&W Method, especially between the second estimates of the percentage of damaged grains (X) and of weight loss (Y7) calculated with the Expanded C&W Method ($P < 0.0001$, the equation $Y7 = 0.36X - 1.15$ (9) accounting for 86% of the global variance: Fig.3).
The 95% confidence interval of the weight loss mean (first estimate with the Expanded C&W Method) obtained from three subsamples of 300 to 400 grains each was $\pm$ 1.9%.
The Multiple TGM Method was used only on 3 samples for which baseline samples had been taken a short time after harvesting. For percentages of damaged grains of respectively 3.4%, 6.0% and 8.5%, the 'aberrant' loss figures of respectively -6.1%, +7.4% and -4.0% were obtained.

DISCUSSION

Results obtained in both Côte d'Ivoire and Central African Republic show that the Count and Weigh Method is more adapted to the constraints of sampling at the village level than the Thousand Grain Mass Method, especially when the chronological approach is used. The 'potential weight loss' estimated with the second expanded C&W measurement appears to be the most accessible biologically unbiased criterion that can be used in field surveys where a minimal equipment is available but where some accuracy is still required.
The main constraint of the TGM Method is that it is highly influenced by sampling hazards since it requires the determination of an adequate baseline sample for each studied sample, which may not be practical. A major cause of imprecision is mean kernel weight variability. Variability within a sample is particularly important in maize, and in sorghum when several varieties are mixed and stored together (case of CAR survey). For paddy rice in CI survey, variability within a sample was low since a single

Table 3. Comparison of different loss estimates in maize grain samples (variety 'Tuxpeno') taken at Soumbé and Poumbaidi seed multiplication centers (CAR) (storage of shelled grain in bags)

# of sample	% damaged grains		% weight loss Simple C&W		Expanded C&W		Multiple TGM
	1st est. (%DG1)	2nd est. (%DG2)	1st est. (sCW1)	2nd est. (sCW2)	1st est. (eCW1)	2nd est. (eCW2)	(mTGM)
1	1.9	13.7	0	1.7	0	1.6	-0.8
2	10.4	13.8	1.4	2.0	1.9	2.4	2.9
3	16.4	19.1	0	1.9	2.7	2.9	1.8
4	9.1	29.2	0.5	2.3	2.0	3.8	4.7
5	30.9	32.1	3.2	3.0	2.6	3.5	7.1
6	45.8	51.1	6.3	7.3	5.8	7.6	12.7
7	33.0	52.1	4.7	7.6	4.8	8.7	7.4
8	31.6	53.0	6.4	8.8	6.2	8.4	7.9
9	57.1	62.5	7.6	8.6	12.2	10.5	15.1
10	65.8	80.7	19.0	17.7	20.3	19.1	12.4

Table 4. Linear correlation coefficients between the different loss estimates in maize samples (variety 'Tuxpeno')

	%DG2	sCW1	sCW2	eCW1	eCW2	mTGM
%DG1	0.937	0.884	0.877	0.897	0.893	0.938
%DG2	1	0.907	0.946	0.897	0.954	0.886

All the coefficients are significant at 99.9% level

Table 5. Comparison of different loss estimates in maize grain samples (variety 'Yellow Dentado Composto') taken at Soumbé and Poumbaïdi seed multiplication centers (CAR) (storage of shelled grain in bags)

# of sample	% damaged grains		% weight loss: Simple C&W		% weight loss: Expanded C&W		% weight loss: Multiple TGM
	1st est. (%DG1)	2nd est. (%DG2)	1st est. (sCW1)	2nd est. (sCW2)	1st est. (eCW1)	2nd est. (eCW2)	(mTGM)
1	0.2	0.2	0	0	0	0	0
2	0.3	0.3	0.1	0	0	0	0.1
3	1.9	2.4	0.9	1.3	0.7	1.2	-0.1
4	2.3	3.5	0.4	0.8	0.7	1.0	3.0
5	4.9	7.0	1.8	2.2	1.6	2.1	-5.3
6	9.0	10.0	2.3	3.0	2.2	3.0	1.4
7	11.3	16.7	3.5	4.8	3.1	4.7	-5.4

Table 6. Linear correlation coefficients between the different loss estimates in maize grain samples (variety 'Yellow Dentado Composto')

	%DG2	sCW1	sCW2	eCW1	eCW2	mTGM
%DG1	0.984***	0.977***	0.978***	0.989***	0.983***	-0.938 NS
%DG2	1	0.982***	0.988***	0.990***	0.992***	-0.575 NS

NS: not significant at 95% confidence level
***: significant at P < 0.001 (for 5 d.f.)

Table 7. Linear correlation coefficients between the different loss estimates in sorghum grain samples (several local varieties threshed and mixed together)

	%DG2	sCW1	eCW1	eCW2
%DG1	0.923***	0.648*	0.941***	0.873***
%DG2	1	0.712**	0.918***	0.947***

*: significant at P < 0.05 (for 11 d.f.)
**: significant at P < 0.01 (for 11 d.f.)
***: significant at P < 0.001 (for 11 d.f.)

variety was sampled at each occasion, whereas variability between two samples could be very high when different varieties were sampled at different occasions.
In addition, TGM (as well as SVW and 'Weigh-In, Weigh-Out') estimates require the accurate measurement of grain moisture, which is either not practical if reference methods (Granovsky *et al.*, 1978) are to be used, or the source of substantial error if electronic moisture meters are used (Reed, 1986), particularly in the case of maize (Martin and Multon, 1982).
The separation of grains into size categories increases the precision of TGM Method concerning mean kernel weight variability within the sample [with reference to the figures given by Proctor and Rowley (1983)], but sampling hazards regarding variability from one sample to another and M.C. measurements remain, and cannot be overcome unless the loss is calculated on one sample, i.e. if the baseline sound sample is determined from the undamaged part of the studied sample. The thus 'Modified (Multiple) TGM Method' is strictly equivalent to the (Expanded) C&W Method.
As for the C&W Method, its main advantage is that the loss due to insects can be estimated independently from the loss due to other causes (or losses due to different species of insects can be recorded independently) on the same sample without requiring M.C. measurement, so that a minimal equipment is needed and that error linked to sampling hazards is considerably reduced. The main objective of the separation into size categories is to reduce the bias introduced by the probable preference of insects for a given category of grains to lay their eggs. When maize cobs are still on the stalk in the field, or at low levels of insect infestation when they are stored with husks, the grains at the top of the ear are more readily damaged than the others because they are not completely protected by husks. On the contrary, if the husks are removed, and furthermore if the ears are shelled, the insects may select larger grains, so that any procedure that compares the individual weights of kernels may result in a negative loss finding, or at least an underestimation of loss. In addition, when grains are heavily infested by primary insect pests, infestation by secondary pests disturbs the relation that exists between exit holes and weight loss.
These observations may explain why the relation between the percentage of damaged grains and the percentage of weight loss are not perfectly linear, but are better adjusted on Log curves in the case of maize, so that if 'conversion factors' (Adams and Schulten, 1978; Pointel and Coquard, 1979) are to be used, they should depend on the level of attack.
For paddy rice, our figure for the mean conversion coefficient (based on underestimations of both the actual percentage of damaged grains and of the weight loss) is of about 1.5 against 2 as published by Adams and Schulten (1978). However, as the parts of the attacked grains that have not been eaten by insects cannot be recovered during paddy dehulling, the percentage of weight loss could be assimilated to the percentage of damaged grains.
In the case of sorghum, a mean conversion factor of 3 could be used (against 4 as published by Adams and Schulten (1978)).
Actually in our study, this conversion factor relies on an overestimation of the weight loss. As a matter of fact, in the variant of the C&W method that was used in CAR, the first estimate of the weight loss is an underestimate of the real loss on the sample, since grains sheltering young insect instars are counted

as 'sound', which artificially diminishes the difference between the calculated mean weight of sound grains and that of attacked grains. On the contrary, the second estimate is an overestimate of the real loss, because it corresponds to the loss that the insects would have caused had all the hidden forms been allowed to develop fully, but not to breed inside the grains. It has thus a precise biological meaning, which is accounted for by the good correlation observed between the percentage of damaged grain (second estimation after incubation, i.e. the actual rate of infestation) and the percentage of weight loss.
Such a good correlation is an indication of both the adaptation of the method, and its amenability to simplification by the use of the CPD Method with conversion coefficients, or regression equations such as the ones established in this paper.
However, this method is no longer applicable in case of high larval mortality, due for instance to heavy parasitism or fumigation. It can then be replaced by the variant of the C&W method involving grain dissection (De Lima, 1979) that, to be practical, unfortunately requires a great rate of subsampling, which diminishes its accuracy.

REFERENCES

Adams J.M. (1978) The chronological approach: Losses as reflected by use patterns, 135-137, In: Harris K.L. and Lindblad C.J., Post-Harvest Grain Loss Assessment Methods, Am. Assoc. of Cereal Chem. St-Paul, MN.

Adams J.M. and Schulten G.G.M. (1978) Losses caused by insects, mites and microorganisms, 83-95, In: Harris K.L. and Lindblad C.J., Post-Harvest Grain Loss Assessment Methods, Am. Assoc. of Cereal Chem. St-Paul, MN.

Anon. (1969) Rapport d'activité de la commission d'évaluation des pertes dans les denrées stockées créée à l'issue du Congrès de Marseille sur la protection des cultures tropicales. Agron. trop. 24, 872-876.

Boxall R.A. (1986) A Critical Review of the Methodology for Assessing Farm-Level Grain Losses After Harvest. Report G191 ,Tropical Development and Research Institute, London.

De Lima C.P.F. (1979) The assessment of losses due to insects and rodents in maize stored for subsistence in Kenya. Trop. stored Prod. Inf. 38, 21-26.

Fleurat-Lessard F. (1984) Mesure de l'infestation par les insectes, 520-541, In: Multon J.L., Conservation et Stockage des Grains et Graines et Produits Dérivés. Lavoisier, Paris.

Golob P. (1976) Techniques for sampling bagged produce. Trop. stored Prod. Inf. 31, 37-48.

Granovsky T.A., Martin G., and J.L. Multon (1978) Moisture measurement, 119-122, In: Harris K.L. and Lindblad C.J., Post-Harvest Grain Loss Assessment Methods, Am. Assoc. of Cereal Chem. St-Paul, MN.

Martin G. and Multon J.L. (1982) Le dosage rapide de l'eau à la réception en organisme stockeur, 492-502, In: Multon J.L., Conservation et Stockage des Grains et Graines et Produits Dérivés. Lavoisier, Paris.

Pointel J.G. and Coquard J. (1979) Le pourcentage de perte en poids et la perte spécifique, critères d'évaluation des dégâts causés par les insectes dans les céréales et légumineuses stockées. Agron. trop. 34, 377-381.

Proctor D.L. and Rowley J.Q. (1983) The Thousand Grain Mass (TGM): A basis for better assessment of weight losses in stored grain. Trop. stored Prod. Inf. 45, 19-23.

Ratnadass A. and B. Sauphanor (1988) Les pertes dues aux insectes sur les stocks paysans de céréales en Côte d'Ivoire, 47-56, In: AUPELF-UREF, Céréales en régions chaudes. Eds John Libbey Eurotext, Paris.

Ratnadass A. (1990) Les pertes occasionnées par les insectes au sorgho stocké dans des villages de République Centrafricaine. Agron. trop., in press.

Reed C. (1986) Characteristics and limitations of methods to estimate losses in stored grain. Special Report N°16, Food & Feed Grain Institute, Kansas State University.

Schulten G.G.M. (1982) Prevention of losses programme. Report on a consultancy mission on loss assessment. FAO, Rome.

AMELIORATION DES METHODES PRATIQUES D'EVALUATION DES PERTES DUES AUX INSECTES DU GRAIN STOCKE AU NIVEAU VILLAGEOIS EN AFRIQUE TROPICALE

A. RATNADASS (1) et F. FLEURAT-LESSARD (2)

(1) IRAT/CIRAD, ICRISAT/West African Sorghum Improvement Program, B.P. 320, Bamako, Mali
(2) INRA, Laboratoire des Insectes des Denrées, B.P. 81 33883 Villenave d'Ornon Cedex, France

Résumé

L'application de certaines variantes de la Méthode des Mille Grains et de la Méthode "Comptage et Pesée" d'évaluation des pertes de poids occasionnées par les insectes pendant le stockage du maïs, du riz paddy et du sorgho dans les villages de Côte d'Ivoire et de la République Centrafricaine a permis d'améliorer significativement la précision de la seconde méthode. Il a été possible, à partir de cette nouvelle méthodologie, d'établir la relation entre les pertes et les caractéristiques des populations d'insectes présentes.

Dans cette étude, réalisée en milieu rural et en parallèle au laboratoire, il a été pris en compte aussi bien la variabilité de taille des grains que les écarts induits par les modèles d'échantillonnage pratiqués par les agriculteurs. Il y est démontré que la deuxième méthode citée est de loin la plus pratique et la plus précise. Les implications de ces résultats sont discutées en vue d'une application ultérieure dans les programmes d'évaluation des pertes,intégrés dans les opérations internationales d'aide au progrès des technologies rurales dans les pays en voie de développement.